[redacted]

April 16, 1964 STATINTL
STATINTL

[redacted]

Subject: Anamorphic Eyepieces for Bausch & Lomb Zoom 70
Stereoscope.

Gentlemen:

Thank you for offering [redacted] the opportunity to pro- STATINTL
pose on your requiremen[redacted]ic Eyepieces.

A detailed technical proposal has been forwarded under separate cover.

Your requirement of 120 days or sooner delivery necessitates that this program be handled as a priority program with special attention throughout all phases. Figure 5 outlines the program schedule which will allow successful completion and delivery of one pair of Anamorphic Eyepieces within 12 weeks after receipt of your order to proceed.

A firm fixed price contract of 12 weeks duration is proposed. Refer to the attached cost breakdown on DD form 633-4 for the elements of cost.

Deliverable items will be:

> One (1) pair of Anamorphic Eyepieces
> Two (2) copies - Manual of Operation
> Monthly Progress Reports.

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If you wish to discuss technical details of the proposed eye-pieces, contact [redacted] and STATINTL will discuss any cost or contractual questions you may have.

To allow you sufficient time to evaluate this quotation, it will remain firm for 30 days.

Very truly yours,

[redacted] ATINTL

ATINTL

[redacted]

15. OVERHEAD RATE AND GENERAL AND ADMINISTRATIVE RATE INFORMATION

A. GOVERNMENT AUDIT PERFORMED	DATE OF AUDIT	ACCOUNTING PERIOD COVERED
[X] YES [ ] NO [ ] PENDING	1963	1962

B. NAME AND ADDRESS OF GOVERNMENT AGENCY MAKING AUDIT

U.S. Naval Audit Office
[redacted]

C. DO YOUR CONTRACTS PROVIDE NEGOTIATED OVERHEAD RATES (ASPR 3-704)? *(If yes, name Agency negotiating rates)*

Yes

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D. *(If no Government rates have been established furnish the following information)*

DEPARTMENT OR COST CENTER	RATE	BASE	TOTAL INDIRECT EXPENSE POOL	BASE FOR TOTAL

16. EXHIBIT A - SUBCONTRACT INFORMATION *(If more space needed, use blank sheets, identifying item number)*

NAME AND ADDRESS OF SUBCONTRACTOR(s)	SUBCONTRACTED WORK	SUBCONTRACT TYPE	SUBCONTRACT AMOUNT

17. EXHIBIT B - OTHER DIRECT COSTS *(Specify. If more space needed, use blank sheets, identifying item number)*

CERTIFICATE

The labor rates and overhead costs are current and other estimated costs have been determined by generally accepted accounting principles. Bidder represents: (a) that he [ ] has, [X] has not, employed or retained any company or person (other than a full-time bona fide employee working solely for the bidder) to solicit or secure his contract, and (b) that he [ ] has, [X] has not, paid or agreed to pay to any company or person (other than a full-time bona fide employee working solely for the bidder) any fee, commission, percentage or brokerage fee, contingent upon or resulting from the award of this contract, and agrees to furnish information relating to (a) and (b) above, as requested by Contracting Officer. *(For interpretation of the representation, including the term 'bona fide employee,' see (Code of Federal Regulations, Title 44, Part 150.)*

Number of contractor employees [X] Over 500 [ ] Under 500

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State incorporated in [redacted]

DATE 4/16/64 [redacted] TIVE OF CONTRACTOR

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April 15, 1964

Program for Design and Manufacture of Anamorphic Eyepieces

[redacted] NTL

1. Summary

A need has arisen for eyepieces having variable anamorphic magnifying power. Specifically two requirements exist. The first is for a 5x eyepiece with a variable 1x to 3x anamorphic magnifying power resulting in an overall 5x to 15x anamorphic magnifying power. The second requirement is similar, the only difference being that the basic magnifying power shall be 10x and hence the anamorphic magnifying power will vary from 10x to 30x. An additional requirement is that at least one pair of eyepieces be delivered in minimum time.

Achievement of the required eyepiece will represent a unique development in the state of the optical art. Both anamorphic and variable power systems are well known. However, rarely have the two types of systems been combined.

Because of the unique nature of the desired unit it may well be that there exists an unusual, unique, and elegant solution to the problem. Time limitations prevent search for such a solution. The solution to be proposed here will therefore be a straightforward combination of existing techniques. While these techniques have never before been combined there is no reason to question whether a successful result can be achieved. The primary problem will be whether the desired anamorphism can be achieved in a reasonable tube length. Excessive extension of the eyepiece tube length cannot be tolerated.

In the following sections three possible approaches to achieve variable anamorphism in an eyepiece are described. Two of these approaches are considered applicable to the present problem, and will be carried along in a parallel effort to assure achievement in a minimum of time of a product having maximum utility.

2. Technical Discussion

2.1 Methods of achieving anamorphic magnification. There exists in present optical technology two means of achieving anamorphic magnification. The first, use of cylinder lenses, works in converging, diverging, or collimated light. It will be indicated later that the last is the preferred mode of use. [redacted]

A second method of achieving anamorphic magnification, which works well only in collimated light, makes use of a prism arrangement. Any standard text on elementary spectrometry explains the phenomena of minimum deviation in a prism. It is easily shown that at minimum deviation the width of the emergent beam just equals the width of the entering beam. At some other angle of deviation the width of the emergent beam differs from that of the entering beam as shown in Fig. 1. The ratio of the width of the entering beam to that of the emergent beam can be shown to just equal the magnifying power. In the case shown in Fig. 1 the anamorphic magnification is accompanied by an undesirable deviation. This can be corrected in practical cases by two prisms in tandem with bases opposite each other as indicated in Fig. 2. Such a unit has recently been constructed for correction of anamorphic distortion in a viewer. The constructed unit has proven satisfactory in every way.

2.2 Application to Eyepiece

No matter which system is used it is desirable that the anamorphic component operate in collimated light. This is essential to the performance of the prism arrangement since use of divergent or convergent light will result in seriously degraded imagery. In the cylinder lens case some seven third order aberrations (unique to cylinder lenses) are automatically zero when the lens is placed in collimated light. Thus, for the sake of speedy design the anamorphic component will be placed in collimated light.

The first element of the anamorphic eyepiece must then be a collimating lens. The first question which arises is whether one should attempt to place a negative lens of correct focal length below the objective image plane to collimate the light, or should a positive lens be placed above the objective image plane to perform this function. The former has the advantage of extreme compactness, but unfortunately it also, as has been experimentally verified, drastically reduces the usable real field of the system. This loss of field is intolerable and it therefore becomes necessary to place a positive lens above the objective image plane to collimate the light from the object. (It is to be noted that this collimation can and probably will be provided by an ordinary eyepiece.).

Means of achieving anamorphic magnifying power were described above. Now means of achieving a variable anamorphic magnifying power must be considered. In the case of the prism system the magnification is varied by changing the angle of the prisms. The prisms, mounted in a simple pivoting mount, are geared together to assure coordinated motion, and the desired variation obtained by appropriately rotating the prisms. For the cylinder lens technique one possibility uses a cylindrical afocal zoom telescope. Such a system has never been made using cylinder lenses, but there are available optically compensated (requiring no complicated cams) afocal zoom systems, having a three to one range. It is not expected that there will be any serious problem in substituting cylindrical lens for spherical lenses in one of these designs.

A third possibility makes use of two separated sets of two cylinders having equal and opposite power. When these are positioned with their cylinder axes parallel they are effectively plane parallel plates and the collimated light passes through them unaffected. Now if one cylinder in each set is rotated slightly there will exist, because of the misaligned cylinder axes, a net effective cylindrical power. By proper choice of parameters it is possible to make (after rotation) one lens pair effectively a positive cylinder and the second lens pair effectively a negative cylinder. One then has, in effect, a cylindrical Galilean telescope yielding the desired anamorphic magnification. The theory of crossed cylinders has been worked out primarily for ophthalmic applications. There exists no theory of the aberrations of thick, misaligned cylinders at the present time. The urgency of the present task precludes development of such a theory. Thus this approach must be ignored for the present despite the fact that it has many features which make it appear desirable as the ultimate solution to the problem.

3. Proposed Program

The development and manufacture of variable anamorphic eyepieces within a minimum period of time will require a maximum effort closely coordinated program. One must anticipate some duplicated effort to assure a solution to the problem. Both the prism and zoom cylinder lens solutions contain certain unknown factors. We see no reason why a zoom cylinder lens should not work as well as a spherical one, but there may be unknown problems that will appear as the design proceeds. The prism system works best around the unity magnifying power position. Thus a prism system having a range of .5x to 1.5x is relatively easy to achieve while one having even a range of 1x to 2x is exceedingly difficult. This difficulty can, as will be seen below, be circumvented by additional complexity of the eyepiece. It is necessary, because of uncertainties involved to carry on parallel programs.

3.1 Zoom Lens Program

The proposed zoom lens solution will consist of a collimating lens, the zoom cylindrical afocal system, a collective lens, and an eyepiece. The arrangement is shown schematically in Figure 3. As can be seen the system is quite long and there would appear to be some danger of loss of field. Preliminary experimentation using a spherical zoom system has indicated that by careful design techniques there should be no loss in usable field.

The crux of this approach is clearly the success of the cylindrical zoom system. If there are no unknown problems in this system the successful completion of the eyepiece will be a straightforward procedure. The experimentation mentioned previously also indicated the length of the unit will be of the order of six inches so that excessive size is not a serious problem. In this portion of the program major emphasis will be placed on design of the zoom cylindrical system.

Once this is achieved the other components can be successfully designed following standard procedures. Time will not permit following a sequential procedure. At the outset of the program the design of the collimating, objective, and field lens portions of the system will be initiated with a "reasonable" space left for the zoom lens. The zoom lens will be carried along as a separate problem and at its successful conclusion the two systems will be combined into one integrated optical unit with perhaps minor revisions of the parameters to balance aberrations.

3.2 Prism System

The prism system arrangement will be similar with the zoom lens replaced by a four component prism arrangement. It has been noted that desirably the prism system should operate about the unity power position. Thus the goal here will be design of a prism system varying from .5x to 1.5x. This while giving the desired three to one range will not give the desired magnifying power range. For instance assuming a nominal 10x eyepiece the anamorphic magnification ranges from 5x to 15x and this result is unacceptable.

To correct this situation a fixed .5x anamorphic system is introduced at ninety degrees to the variable anamorphic power. Thus with the variable power at .5x (and assuming a 10x eyepiece) the apparent spherical magnifying power is 5x. Thus the anamorphic power ranges from 1x to 3x times the spherical magnifying power as is required. Fig. 4 shows an optical schematic of the system.

Were it not for the required fixed anamorphic portion of the system there would be no question that this is the better approach. This system too has been the subject of a preliminary experimental investigation. In this investigation it was not possible to fit a fixed anamorphic system into the optical train. With this omission the system worked very satisfactorily.

There is little question that the required fixed anamorphic system can be designed. The primary question is how much does it lengthen the system, and will there be a serious loss of field? These questions can be answered only at the design stage.

The design of the prism anamorphic portion of the system is straightforward and because of our recent experience with this arrangement, quite rapid. The overall effort will be divided into two phases. The first will be to design a compact, fixed, anamorphic .5x afocal unit, and the second the design of the remainder of the system. These two phases will be parallel efforts.

3.3 Interpupillary Distance

The variable anamorphic eyepieces will be of the order of five to six inches long. The eyepiece tubes of the Zoom 70 diverge at an angle of approximately seven degrees. If the new eyepieces were to be made straight, measurement shows that the minimum interpupillary distance will be 60mm which is unacceptable. To correct this it is planned to introduce a small wedge (not shown in Figures 3 and 4) to bend the optical path so that it will be parallel to the center line of the instrument. Thus the eyepieces will be parallel and the minimum interpupillary distance will equal that of the normal Zoom 70.

The existence of these wedges will necessitate rotational alignment of the eyepiece in the instrument. A clamp will be provided to permit locking the eyepiece when proper adjustment has been achieved. Rotational adjustment of the anamorphic axis will be achieved by introduction of a bearing above the locked portion of the unit.

3.4 Total Design Effort

The successful completion of this effort is primarily a scheduling problem. Thus, at the outset, cut off times must be chosen. The two approaches will be initiated immediately and will proceed for two weeks. At that time progress will be reviewed to determine whether there is a clear indication as to which approach will be more successful. If the decision is clear cut then one effort will be dropped and material (which is a relatively long lead time item) for the chosen system will be ordered. If the decision is not clear cut then material for both systems will be ordered. In either event the design will continue for two more weeks.

At the end of one month all design effort will cease and drawings will be released for manufacture. This is a short design cycle and may result in a design which is usable but not optimized. Some residual aberrations may exist but these will not seriously degrade performance.

3.5 Mechanical Design

Mechanical design assistance will be brought into the program at its inception. There can be no actual design effort at this stage but the designer can be apprised of the approximate configuration and can begin consideration of the design approach. As the optical design becomes firmer the mechanical designer will begin preliminary layouts. Mechanical design for both approaches will be carried along until such time as the preferred approach is chosen. By maintaining close liaison with the optical design it is anticipated that the mechanical designer will complete drawings suitable for model shop use within one week after completion of the optical design.

3.6 Manufacture and Assembly

The manufacturing organization will be apprised of the date to expect receipt of drawings and the urgency of this task. As noted above material will be ordered in advance of design completion so that material will be available. Under these conditions the optical components will be completed within five weeks after release for manufacture.

Mechanical parts will be manufactured as soon as the mechanical designer releases drawings.

There will be no problem in completing manufacture of mechanical components before completion of the optical components.

Assembly of the units will require one week. Evaluation, alignment and de-bugging will require an additional one to two weeks depending on what problems may arise. Thus the units will be completed twelve weeks after the receipt of the order.

Ordinarily the schedule is not considered a part of the proposed solution. In the present case, however, time limitations are as much a part of the problem as technical problems. Therefore the schedule has been made part of the proposed solution. Fig. 5 shows a bar chart of the anticipated time schedule.

4. Work Statement

[redacted] proposes to design and manufacture and deliver one pair of variable anamorphic eyepieces. The basic power of the eyepieces (either 5x or 10x) will be determined early in the program.

Design goals for these eyepieces will be as follows:

1. Basic 5x or 10x eyepiece with magnification variable in one direction from 5x to 15x for the 5x eyepiece and 10x to 30x for the 10x eyepiece. Which power will be chosen will be decided within the first two weeks of the design effort.

2. The maximum acceptable loss of field will be 15% and every effort will be made to minimize this loss.

3. Anamorphic direction will be adjustable through 360°.

4. There will be no more than 20% loss of resolution using these eyepieces as compared to use of an eyepiece of comparable magnifying power. Every effort will be made to minimize performance losses.

5. Maximum length of the eyepiece will be six inches. This distance to be measured from the shoulder that rests on top of the Zoom 70 eyepiece holder to the top of the uppermost lens.

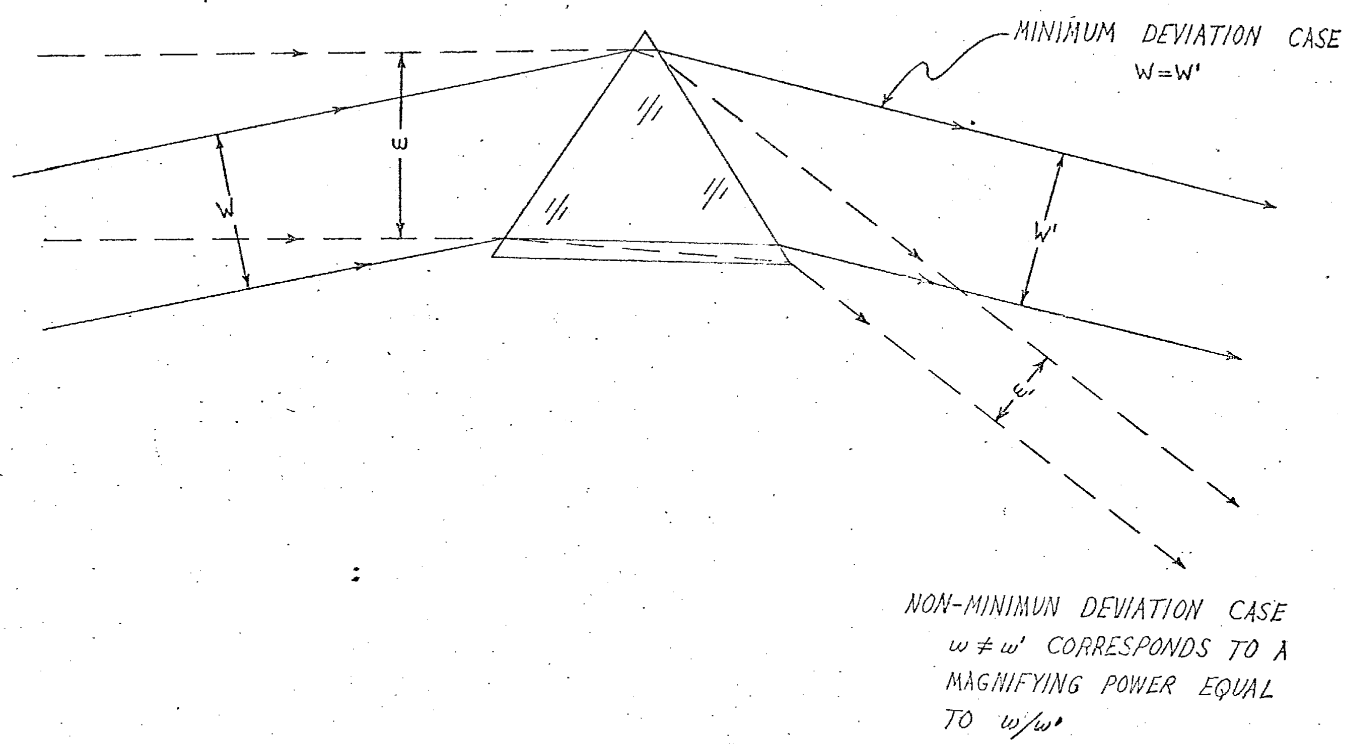

FIG. I. DIAGRAM SHOWING MAGNIFYING POWER OF PRISM.

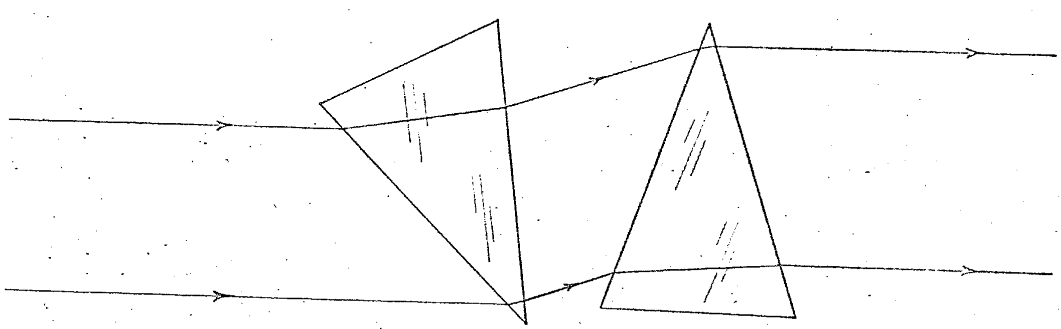

FIG. 2. SCHEMATIC OF A TWO PRISM ANAMORPHIC SYSTEM.

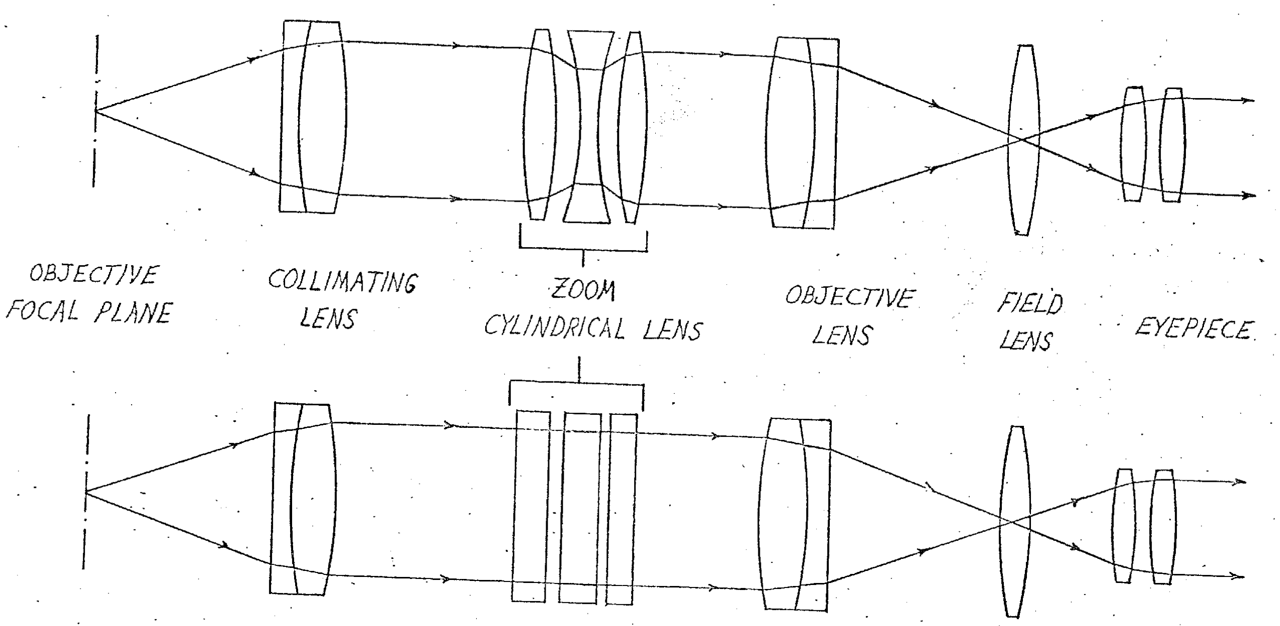

FIG. 3 SCHEMATIC OF ZOOM CYLINDER LENS VARIABLE ANAMORPHIC EYEPIECE.

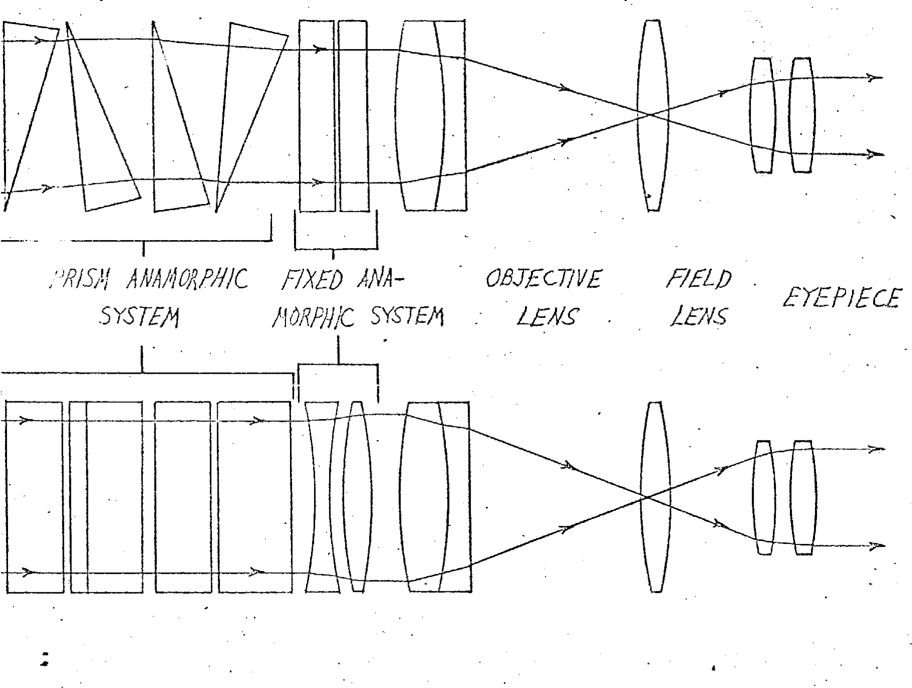

DIAGRAM OF PRISM VARIABLE ANAMORPHIC EYEPIECE.

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